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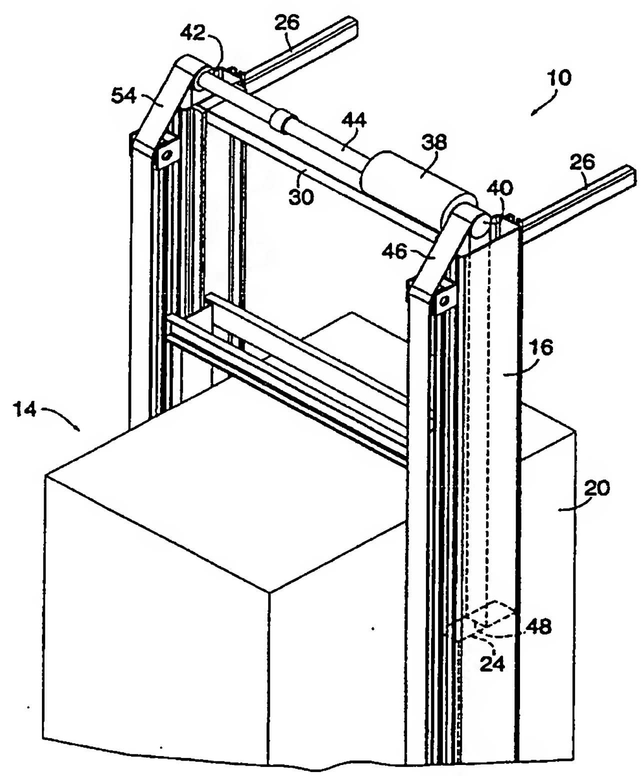
(57) Abstract

An elevator system includes a hoistway defined in a surrounding structure, and an elevator car and at least one counterweight disposed in the hoistway. The hoistway defines an overhead space over a vertical extent of the hoistway between a ceiling of the hoistway and a top portion of the elevator car at its highest operable location along the hoistway. At least one drive motor is disposed in the overhead space and drivingly couples and suspends the elevator car via at least one flat rope or belt.



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ELEVATOR SYSTEM WITH OVERHEAD DRIVE MOTOR

FIELD OF THE INVENTION

The present invention relates generally to an elevator system, and more particularly to an elevator system including a drive motor provided at an overhead level within the hoistway between an elevator car and hoistway ceiling.

BACKGROUND OF THE INVENTION

Considerable expense is involved in the construction of a machine room for an elevator. The expense includes the cost of constructing the machine room, the structure required to support the weight of the machine room and elevator equipment, and the cost of shading adjacent properties from sunlight (e.g., sunshine laws in Japan and elsewhere).

It is an object of the present invention to provide an elevator system without a machine room which avoids the above-mentioned drawbacks associated with prior elevator systems.

It is another object of the present invention to employ flat ropes or belts to reduce the size of either conventional or flat drive motors in the overhead of the hoistway, and thereby reduce the overall size and cost of constructing the hoistway.

SUMMARY OF THE INVENTION

An elevator system includes a hoistway defined in a surrounding structure, and an elevator car and at least one counterweight disposed in the hoistway. The hoistway defines an overhead space over a vertical extent of the hoistway between a ceiling of the hoistway and a top portion of the elevator car at its highest operable location along the hoistway. At least one drive motor is disposed in the overhead space and drivingly couples and suspends the elevator car via at least one flat rope or belt.

An advantage of the present invention is that avoiding the construction of a machine room significantly reduces the cost of elevator installation and construction.

A second advantage of the present invention is that the employment of flat ropes or belts reduces the size of conventional or

flat drive motors to thereby reduce the space in the overhead of the hoistway needed to accommodate the drive motors.

A third advantage of the present invention is the provision of several alternative drive motor locations in the overhead space.

Other advantages will be made apparent with references to the specification and accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic, partial, front perspective view of an elevator system having the drive motor disposed in the overhead space of the hoistway in accordance with the present invention.

FIG. 2 is a schematic, partial, rear perspective view of the elevator system of FIG. 1.

FIG. 3 is a schematic, partial, rear perspective view of an elevator system employing synchronously driven motors in accordance with a second embodiment of the present invention.

FIG. 4 is a schematic, partial, side elevational view of an elevator system having a 2:1 roping configuration in accordance with a third embodiment of the present invention.

FIG. 5 is a schematic, partial, perspective view of an underslung elevator system in accordance with a fourth embodiment of the present invention.

FIG. 6 is a schematic, partial, perspective view of an underslung elevator system in accordance with a fifth embodiment of the present invention.

FIG. 7 is a schematic, partial view illustrating the roping configuration of an underslung elevator system in accordance with a sixth embodiment of the present invention.

FIG. 8 is a schematic, partial, perspective view of the elevator system of FIG. 7.

FIG. 9 is a schematic, partial, perspective view of an overslung elevator system in accordance with an seventh embodiment of the present invention.

FIG. 10 is a sectional, side view of a traction sheave and a plurality of flat ropes, each having a plurality of cords.

FIG. 11 is a sectional view of one of the flat ropes.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. 1 and 2, an elevator system embodying the present invention is generally designated by the reference number 10. The elevator system 10 includes a hoistway 12 defined by the surrounding structure of a building. An elevator car 14 is disposed in the hoistway 12 for upward and downward movement therealong. First and second support columns 16, 18 each extend along a vertical extent of the hoistway 12 associated with elevator car travel, and are respectively disposed adjacent to oppositely facing sidewalls 20, 22 of the elevator car 14. Each of the first and second support columns 16, 18 defines a hollow interior or recess for accommodating an associated counterweight 24 (only one shown) for vertical movement along the associated support column. As shown in FIGS. 1 and 2, brackets 26, 26 extend frontwardly from the first and second support columns 16, 18 for attachment to a front sidewall 28 of the hoistway 12.

A support member 30 extends generally horizontally between and is mounted on the first and second support columns 16, 18 in an overhead space 32 of the hoistway 12 defined by the vertical length or extent "V" of the hoistway between a ceiling 34 of the hoistway and a top portion or ceiling 36 of the elevator car 14 at its highest operable position within the hoistway. A drive motor 38 is mounted on the support member 30 in the overhead space 32, and is shown in FIG. 1 to be positioned substantially over the ceiling 36 of the elevator car 14. A first drive sheave 40 is drivingly coupled to the drive motor 38 and is disposed over the first support column 16. A second drive sheave 42 is drivingly coupled to the drive motor 38 via an elongated drive shaft 44, and is disposed over the second support column 18. A first flat, flexible rope or belt 46, has a first end 48 coupled to a top portion of the counterweight 24 which is disposed within the first support column 16 and a second end 50 (see FIG. 1) coupled to the sidewall 20 of the elevator car 14. The flat rope 46 extends upwardly from its first end 48, loops generally 180° about the

first drive sheave 40, and extends downwardly and terminates at its second end 50 at an underside 52 of the elevator car 14. A second flat rope 54 is similarly configured with the second drive sheave 42 to couple the counterweight 24 which is disposed in the second support column 18 to the elevator car 14, thereby forming a twin roping configuration.

The employment of flat ropes or belts permits smaller drive motors and sheaves to drive and suspend elevator car and counterweight loads relative to drive motors and sheaves using conventional round ropes. The diameter of drive sheaves used in elevators with conventional round ropes is limited to 40 times the diameter of the ropes, or larger, due to fatigue of the ropes as they repeatedly conform to the diameter of the sheave and straighten out. Flat ropes or belts have an aspect ratio greater than one, where aspect ratio is defined as the ratio of rope or belt width w to thickness t (Aspect Ratio = w/t). Therefore flat ropes or belts are stretched out and inherently thin relative to conventional round ropes. Being thin, there is less bending stress in the fibers when the belt is wrapped around a given diameter sheave. This allows the use of smaller diameter traction sheaves. Torque is proportional to the diameter of the traction sheave. Therefore, the use of a smaller diameter traction sheave reduces motor torque. Motor size (rotor volume) is roughly proportional to torque; therefore, although the mechanical output power remains the same regardless of sheave size, flat ropes or belts allow the use of a smaller drive motor operating at a higher speed relative to systems using conventional round ropes. Consequently, smaller conventional and flat drive motors may be accommodated in the overhead space of the hoistway which significantly reduces the size and construction cost of the overhead space.

In summary, reducing the machine size (i.e., drive motor and sheaves) has a number of advantages. First, the smaller machine reduces the overhead space requirement when the machine is located above the elevator car. This can potentially allow the building to be constructed with a flat roof to thereby reduce building construction costs and to comply with sunshine laws. Second, a small machine utilizes less material, and will be less costly to produce relative to a

larger machine. Third, the light weight of a small machine reduces the time for handling the machine and the need for equipment to lift the machine into place so as to significantly reduce installation cost. Fourth, low torque and high speed allow the elimination of gears, which are costly. Further, gears can cause vibrations and noise, and require maintenance of lubrication. Geared machines may also be used, but the present invention is particularly advantageous for gearless machines.

Flat ropes or belts also distribute the elevator and counterweight loads over a greater surface area on the sheaves relative to round ropes for reduced specific pressure on the ropes, thus increasing its operating life. Furthermore, the flat ropes or belts may be made from a high traction material such as urethane or rubber jacket with fiber or steel reinforcement.

FIG. 3 schematically illustrates an elevator system 100 which is similar to the elevator system 10 of FIGS. 1 and 2 except for the implementation of the drive motor and the elimination of the support member 30. As shown in FIG. 3, first and second drive motors 102, 104 and associated first and second drive sheaves 106, 108 are respectively supported on the first and second support columns 16, 18. A synchronizing means 110, such as a controller, causes the first and second drive sheaves 106, 108 to rotate synchronously with one another.

FIG. 4 schematically shows an elevator system 200 having a 2:1 roping configuration which may be employed as a modification to the elevator systems of FIGS. 1-3. (In other words, the elevator car moves a half unit of distance for each unit of distance moved by the rope about the drive sheave.) Like elements with the previous embodiments are labeled with like reference numbers. Because the roping configuration components on each side of the elevator car 14 are similar, the twin roping configuration and components will only be shown and explained with respect to one side of the elevator car.

Roping ratios act similarly to gears. A 2:1 roping arrangement will reduce the motor torque by a factor of two while increasing the motor speed by a factor of two for a given diameter.

This results in a smaller motor since the limiting factor for the motor tends to be torque, as opposed to speed. An additional advantage of 2:1 roping is a reduction of the sheave shaft load, i.e., the radial force applied to the drive motor from the ropes. This reduces the motor size by allowing smaller bearings. The radial load removed from the drive sheave is carried by the rope hitch points. The total amount of rope used in 1:1 or 2:1 configurations is roughly the same. Ropes for 2:1 configurations are about twice as long as ropes for 1:1. However, ropes for 2:1 configurations carry half the load and may have a smaller cross section or be fewer in number. The above-mentioned advantages are also the same for higher numbered roping configurations, such as 4:1 roping.

As shown in FIG. 4, the elevator system 200 includes a deflector sheave 202 mounted on a top portion of a support column 16, and is located adjacent to and below a drive motor 204 and associated drive sheave 206. A counterweight sheave 208 is coupled to a top portion of a counterweight 210, and an elevator sheave 212 is coupled to an underside of the elevator car 14. A flat rope 214 has first and second ends 216, 218 coupled to an overhead portion of the hoistway, preferably at a top portion of the support column 16. The flat rope 214 extends downwardly from its first end 216, loops generally 180° about the elevator sheave 212, extends upwardly and arcs slightly about the deflector sheave 202 and loops generally 180° about the drive sheave 206, extends downwardly and loops generally 180° about the counterweight sheave 208, and extends upwardly and terminates at its second end 218.

FIGS. 5-9 show further embodiments of elevator systems having drive motors disposed in the overhead space of the hoistway in accordance with the present invention. These embodiments employ roping configurations which undersling (FIGS. 5-8) or oversling (FIG. 9) an elevator car and which employ conventional T-shaped guide rails as opposed to the hollow support columns of FIGS. 1-4.

The underslung roping configurations of FIGS. 5-8, as well as the twin roping configurations of FIGS. 1-4, both lift the elevator car from the bottom and symmetrically about the center of gravity so that the elevator car is balanced. Balancing the elevator car

reduces the load on the elevator guides so as to provide superior ride quality. Neither of these configurations requires overslung hardware on the top of the elevator car, and consequently overhead space is minimized. An underslung configuration requires a counterweight only on one side of the elevator car such that the clearance between the elevator car or hoistway and counterweight on one side of the hoistway is eliminated. This allows the underslung elevator car to use a smaller hoistway. On the other hand, the twin arrangement uses fewer sheaves with a 1:1 roping configuration, and may exhibit less vibration and noise than the underslung systems.

FIG. 5 schematically illustrates an elevator system 400 employing a roping configuration which underslings an elevator car 14 in accordance with the present invention. The elevator system 400 includes a drive motor 402 and associated drive sheave 404 disposed in the overhead portion of a hoistway 12 and aligned along a vertically extending portion of the hoistway between the elevator car 14 and a sidewall 420 of the hoistway. The elevator car 14 has elevator sheaves 406, 406 (only one shown) coupled to its underside at opposite sides of the elevator car relative to each other. A counterweight 410 and counterweight sheave 412 coupled to a top portion of the counterweight are disposed within the vertically extending portion of the hoistway 12 between the elevator car 14 and the adjacent sidewall 420 of the hoistway, and are situated below the drive motor 402. A flat rope or belt 414 has first and second ends 416, 418 fixed within a top portion of the hoistway 12, such as a ceiling or sidewall of the hoistway. The flat rope 414 extends downwardly from its first end 416, loops generally 180° about the counterweight sheave 412, extends upwardly and loops generally 180° about the drive sheave 404, extends downwardly and underslings the elevator car 14 via the elevator sheaves 406, 406, and extends upwardly and terminates at its second end 418.

As can be seen in FIG. 5, the rotational axis of the drive motor 402 is oriented at oblique angles relative to sidewalls 420-426 of the hoistway 12. The orientation of the drive motor 402 permits the drive sheave 404 to project into a vertically extending space along the hoistway 12 between a sidewall 428 of the elevator car 14 and the

sidewall 420 of the hoistway where the counterweight 410 is disposed, whereby the need is eliminated for a deflector sheave to direct the flat rope or belt 414 from the drive sheave 404 and into the vertically-extending space for communication with the counterweight 410. Fewer sheaves results in lower cost and better performance because there are fewer components which may malfunction.

FIG. 6 shows an elevator system 600 including a drive motor 602 and associated drive sheave 604 disposed entirely over a ceiling 36 of an elevator car 14 in the overhead space of a hoistway 12. First and second deflector sheaves 606, 608 are disposed in the overhead space of the hoistway 12 and within the vertically extending space along the hoistway between the elevator car 14 and a sidewall 610 of the hoistway. The first and second deflector sheaves 606, 608 cooperate to direct a flat rope or belt 612 from this vertically extending space to the drive sheave 604 and back to the vertically extending space where a counterweight 614 is disposed. The system 600 of FIG. 6 provides more space for the drive motor as compared with the system 400 of FIG. 5. The additional space may be necessary in circumstances where the drive motor does not fit as shown in FIG. 5.

FIGS. 7 and 8 respectively show a simplified, schematic, side view and front perspective view of an elevator system 900 employing a 4:1 roping configuration which means that an elevator car moves one unit of distance for four units of distance moved by a rope over the drive sheave. To better illustrate the roping configuration, the elevator car is not illustrated in FIG. 7.

An elevator car 14 disposed within a hoistway 12 has first and second elevator sheaves 902, 904 coupled underneath the elevator car and at opposite sides of the elevator car relative to each other. Third and fourth elevator sheaves 906, 908 are also coupled underneath the elevator car 14 and at opposite sides of the elevator car relative to each other. As best shown in FIG. 8, the first and second elevator sheaves 902, 904 are located on opposite sides of the elevator car 14 relative to the third and fourth elevator sheaves 906, 908. A counterweight 910 disposed within the hoistway 12 has first and second counterweight sheaves 912, 914 coupled to a top portion of the counterweight.

A drive motor 916, associated drive sheave 918, and first and second deflector sheaves 920, 922 are situated in the overhead space of the hoistway 12. As best shown in FIG. 7, a flat rope or belt 924 has a first and second ends 926, 928 to be coupled to a top portion of the hoistway 12. The flat rope 924 extends downwardly from its first end 926, generally loops 180° about the first counterweight sheave 912, extends upwardly and generally loops 180° about the first deflector sheave 920, extends downwardly and generally loops 180° about the second counterweight sheave 914, extends upwardly and generally loops 180° about the drive sheave 918, extends downwardly and underslings the elevator car 14 via the first and second elevator sheaves 902, 904, extends upwardly and generally loops 180° about the second deflector sheave 922, extends downwardly and underslings the elevator car via the third and fourth elevator sheaves 906, 908, and extends upwardly and terminates at its second end 928. The 4:1 roping configuration provides mechanical advantage to permit the flat rope 924 to move a relatively heavy load in comparison with a 1:1 or 2:1 roping configuration.

FIG. 9 illustrates an elevator system 1000 employing first and second elevator sheaves 1002, 1004 coupled to a ceiling 36 (overslung roping arrangement) of an elevator car 14 at opposite sides of the elevator car relative to each other. A drive motor 1006 and associated drive sheave 1008 are disposed in the overhead space of a hoistway 12 over a ceiling 36 of the elevator car 14. A deflector sheave 1010 is disposed in the overhead space of the hoistway 12 and extends into a vertically extending space along the hoistway between the elevator car 14 and a sidewall 1012 of the hoistway where a counterweight 1014 and counterweight sheave 1016 are provided. A flat rope or belt 1018 has first and second ends 1020, 1022 coupled to a top portion of the hoistway 12. The flat rope 1018 extends downwardly from its first end 1020, generally loops 180° about the counterweight sheave 1016, extends upwardly and arcs slightly about the deflector sheave 1010 and then generally loops 180° about the drive sheave 1008, extends downwardly and generally loops 90° about the first elevator sheave 1002, extends generally horizontally and generally loops 90° about the second elevator sheave 1004, and extends

upwardly and terminates at its second end 1022.

The overslung roping arrangement allows easy access to the sheaves and ropes for maintenance and installation. If the configuration shown in FIG. 9 is rotated 90°, it allows the use of a wide elevator car with the counterweight in the rear. Underslung arrangements cannot be used with the counterweight in the rear since the ropes would pass in front of the elevator doors, or else many deflector sheaves and undesirable rope twists would occur.

A principal feature of the present invention is the flatness of the ropes used in the above described elevator system. The increase in aspect ratio results in a rope that has an engagement surface, defined by the width dimension "w", that is optimized to distribute the rope pressure. Therefore, the maximum rope pressure is minimized within the rope. In addition, by increasing the aspect ratio relative to a round rope, which has an aspect ratio equal to one, the thickness "t1"of the flat rope (see FIG. 11) may be reduced while maintaining a constant cross-sectional area of the portions of the rope supporting the tension load in the rope.

As shown in FIG. 10 and 11, the flat ropes 722 include a plurality of individual load carrying cords 726 encased within a common layer of coating 728. The coating layer 728 separates the individual cords 726 and defines an engagement surface 730 for engaging the traction sheave 724. The load carrying cords 726 may be formed from a high-strength, lightweight non-metallic material, such as aramid fibers, or may be formed from a metallic material, such as thin, high-carbon steel fibers. It is desirable to maintain the thickness "d" of the cords 726 as small as possible in order to maximize the flexibility and minimize the stress in the cords 726. In addition, for cords formed from steel fibers, the fiber diameters should be less than .25 millimeters in diameter and preferably in the range of about .10 millimeters to .20 millimeters in diameter. Steel fibers having such diameter improve the flexibility of the cords and the rope. By incorporating cords having the weight, strength, durability and, in particular, the flexibility characteristics of such materials into the flat ropes, the traction sheave diameter "D" may be reduced while maintaining the maximum rope pressure within acceptable limits.

The engagement surface 730 is in contact with a corresponding surface 750 of the traction sheave 724. The coating layer 728 is formed from a polyurethane material, preferably a thermoplastic urethane, that is extruded onto and through the plurality of cords 726 in such a manner that each of the individual cords 726 is restrained against longitudinal movement relative to the other cords 726. Other materials may also be used for the coating layer if they are sufficient to meet the required functions of the coating layer: traction, wear, transmission of traction loads to the cords and resistance to environmental factors. It should be understood that although other materials may be used for the coating layer, if they do not meet or exceed the mechanical properties of a thermoplastic urethane, then the benefits resulting from the use of flat ropes may be reduced. With the thermoplastic urethane mechanical properties the traction sheave 724 diameter is reducible to 100 millimeters or less.

As a result of the configuration of the flat rope 722, the rope pressure may be distributed more uniformly throughout the rope 722. Because of the incorporation of a plurality of small cords 726 into the flat rope elastomer coating layer 728, the pressure on each cord 726 is significantly diminished over prior art ropes. Cord pressure is decreased at least as $n^{-1/2}$, with n being the number of parallel cords in the flat rope, for a given load and wire cross section. Therefore, the maximum rope pressure in the flat rope is significantly reduced as compared to a conventionally roped elevator having a similar load carrying capacity. Furthermore, the effective rope diameter 'd' (measured in the bending direction) is reduced for the equivalent load bearing capacity and smaller values for the sheave diameter 'D' may be attained without a reduction in the D/d ratio. In addition, minimizing the diameter D of the sheave permits the use of less costly, more compact, high speed motors as the drive machine.

A traction sheave 724 having a traction surface 750 configured to receive the flat rope 722 is also shown in FIG. 10. The engagement surface 750 is complementarily shaped to provide traction and to guide the engagement between the flat ropes 722 and the sheave 724. The traction sheave 724 includes a pair of rims 744 disposed on opposite sides of the sheave 724 and one or more dividers

745 disposed between adjacent flat ropes. The traction sheave 724 also includes liners 742 received within the spaces between the rims 744 and dividers 745. The liners 742 define the engagement surface 750 such that there are lateral gaps 754 between the sides of the flat ropes 722 and the liners 742. The pair of rims 744 and dividers, in conjunction with the liners, perform the function of guiding the flat ropes 722 to prevent gross alignment problems in the event of slack rope conditions, etc. Although shown as including liners, it should be noted that a traction sheave without liners may be used.

Although this invention has been shown and described with respect to an exemplary embodiment thereof, it should be understood by those skilled in the art that the foregoing and various other changes, omissions, and additions in the form and detail thereof may be made therein without departing from the spirit and scope of the invention. Accordingly, the present invention as shown and described in the various embodiments has been presented by way of illustration rather than limitation.

WHAT IS CLAIMED IS:

1. An elevator system, comprising:

a hoistway defined in a surrounding structure;

an elevator car and at least one counterweight disposed in the hoistway, the hoistway defining an overhead space over a vertical extent of the hoistway between a ceiling of the hoistway and a top portion of the elevator car at its highest operable location along the hoistway;

at least one drive motor disposed in the overhead space and drivingly coupling and suspending the elevator car via at least one flat rope.

2. An elevator system as defined in claim 1, further including first and second support columns each extending vertically along a vertical portion of the hoistway associated with elevator car travel, the first and second support columns being disposed adjacent opposite sidewalls of the elevator car relative to each other, and wherein the drive motor is mounted on at least one of the first and second support columns.

3. An elevator system as defined in claim 2, wherein the first and second support columns are generally hollow, and the at least one counterweight includes first and second counterweights respectively disposed within the first and second support columns.

4. An elevator system as defined in claim 3, further including a support member extending generally horizontally between and mounted on the first and second support members in the overhead space for supporting the drive motor, first and second drive sheaves rotatably coupled to the drive motor and respectively disposed adjacent the first and second support columns in the overhead space, and wherein the at least one flat rope includes first and second flat ropes respectively engaging the first and second drive sheaves to couple a respective first and second counterweight to the elevator car.

5. An elevator system as defined in claim 3, further including a support member extending generally horizontally between and mounted on the first and second support members in the overhead space for supporting the drive motor, first and second drive sheaves respectively disposed adjacent the first and second support columns in the overhead space, means for rotatably coupling the drive motor to the first and second drive sheaves, first and second deflector sheaves coupled to the elevator car, first and second counterweight sheaves respectively coupled to top portions of the first and second counterweights, first and second elevator sheaves coupled to the elevator car, and the at least one flat rope including first and second flat ropes, the first and second flat ropes having first ends fixed within the overhead space of the hoistway, extending downwardly and respectively looping about the first and second counterweight sheaves, extending upwardly and respectively looping about the first and second drive sheaves, extending downwardly via respective first and second deflector sheaves and respectively looping about the first and second elevator sheaves and extending upwardly and terminating at second ends fixed within the overhead space of the hoistway.

6. An elevator system as defined in claim 5, wherein the first ends of the first and second flat ropes are respectively coupled to the first and second support columns, and the second ends of the first and second flat ropes are respectively coupled to the first and second support columns.

7. An elevator system as defined in claim 3, wherein the at least one drive motor includes first and second drive motors and associated first and second drive sheaves respectively supported on the first and second support columns in the overhead space, the at least one flat rope includes first and second flat ropes respectively engaging the first and second drive sheaves to couple a respective first and second counterweight to the elevator car, and further including means for synchronizing the rotation of the first and second drive sheaves with each other.

8. An elevator system as defined in claim 7, wherein the synchronizing means includes a controller.

9. An elevator system as defined in claim 3, wherein the at least one drive motor includes first and second drive motors and associated first and second drive sheaves respectively supported on the first and second support columns in the overhead space, and further including means for synchronizing the rotation of the first and second drive sheaves with each other, first and second deflector sheaves coupled to the elevator car, first and second counterweight sheaves respectively coupled to top portions of the first and second counterweights, first and second elevator sheaves coupled to the elevator car, and the at least one flat rope including first and second flat ropes, each of the flat ropes having a first end fixed within the overhead space of the hoistway, extending downwardly and looping about a respective counterweight sheave, extending upwardly and looping about a respective drive sheave, extending downwardly via a respective deflector sheave and looping about a respective elevator sheave, and extending upwardly and terminating at a second end fixed within the overhead space of the hoistway.

10. An elevator system as defined in claim 9, wherein the first ends of the first and second flat ropes are respectively coupled to the first and second support columns, and the second ends of the first and second flat ropes are respectively coupled to the first and second support columns.

11. An elevator system as defined in claim 9, wherein the synchronizing means includes a controller.

12. An elevator system as defined in claim 1, further including a drive sheave drivingly coupled to the drive motor, a counterweight sheave coupled to a top portion of the counterweight, and at least one elevator sheave coupled to an underside of the elevator car, the flat rope having first and second ends each fixed within the overhead space of the hoistway, the flat rope extending downwardly from its first end, looping about the counterweight sheave, extending upwardly and looping about the drive sheave, extending downwardly and underslinging the elevator car via the at least one elevator sheave, and extending upwardly and terminating at its second end.

13. An elevator system as defined in claim 1, further including a drive sheave drivingly coupled to the drive motor, a counterweight sheave coupled to a top portion of the counterweight, and at least one elevator sheave coupled to a top portion of the elevator car, the flat rope having first and second ends each fixed within the overhead space of the hoistway, the flat rope extending downwardly from its first end, looping about the counterweight sheave, extending upwardly and looping about the drive sheave, extending downwardly and overslinging the elevator car via the at least one elevator sheave, and extending upwardly and terminating at its second end.

14. An elevator drive system as defined in claim 1, further including a drive sheave drivingly coupled to the drive motor, first and second counterweight sheaves coupled to a top portion of the counterweight, first and second elevator sheaves coupled underneath the elevator car, third and fourth elevator sheaves coupled underneath the elevator car at an opposite side of the elevator car relative to the first and second elevator sheaves, and first and second deflector sheaves disposed within the overhead space of the hoistway, the flat rope having first and second ends each fixed within the overhead space of the hoistway, the flat rope extending downwardly from its first end, looping about the first counterweight sheave, extending upwardly and looping about the first deflector sheave, extending downwardly and looping about the second counterweight sheave, extending upwardly and looping about the drive sheave, extending downwardly and underslinging the elevator car via the first and second elevator sheaves, extending upwardly and looping about the second deflector sheave, extending downwardly and underslinging the elevator car via the third and fourth elevator sheaves, and extending upwardly and terminating at its second end.

15. An elevator system as defined in claim 1, wherein the drive motor is gearless.

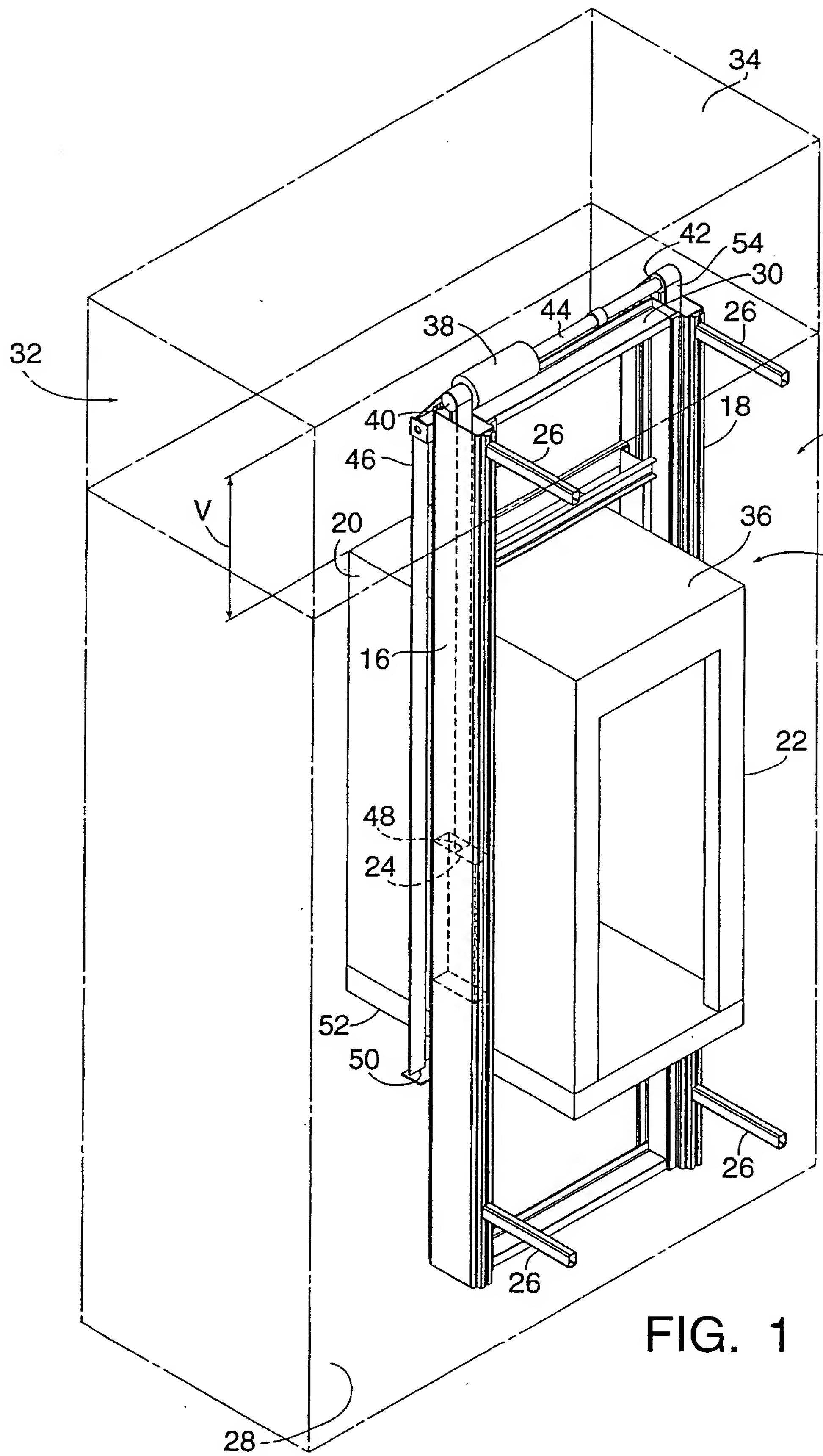
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FIG. 1

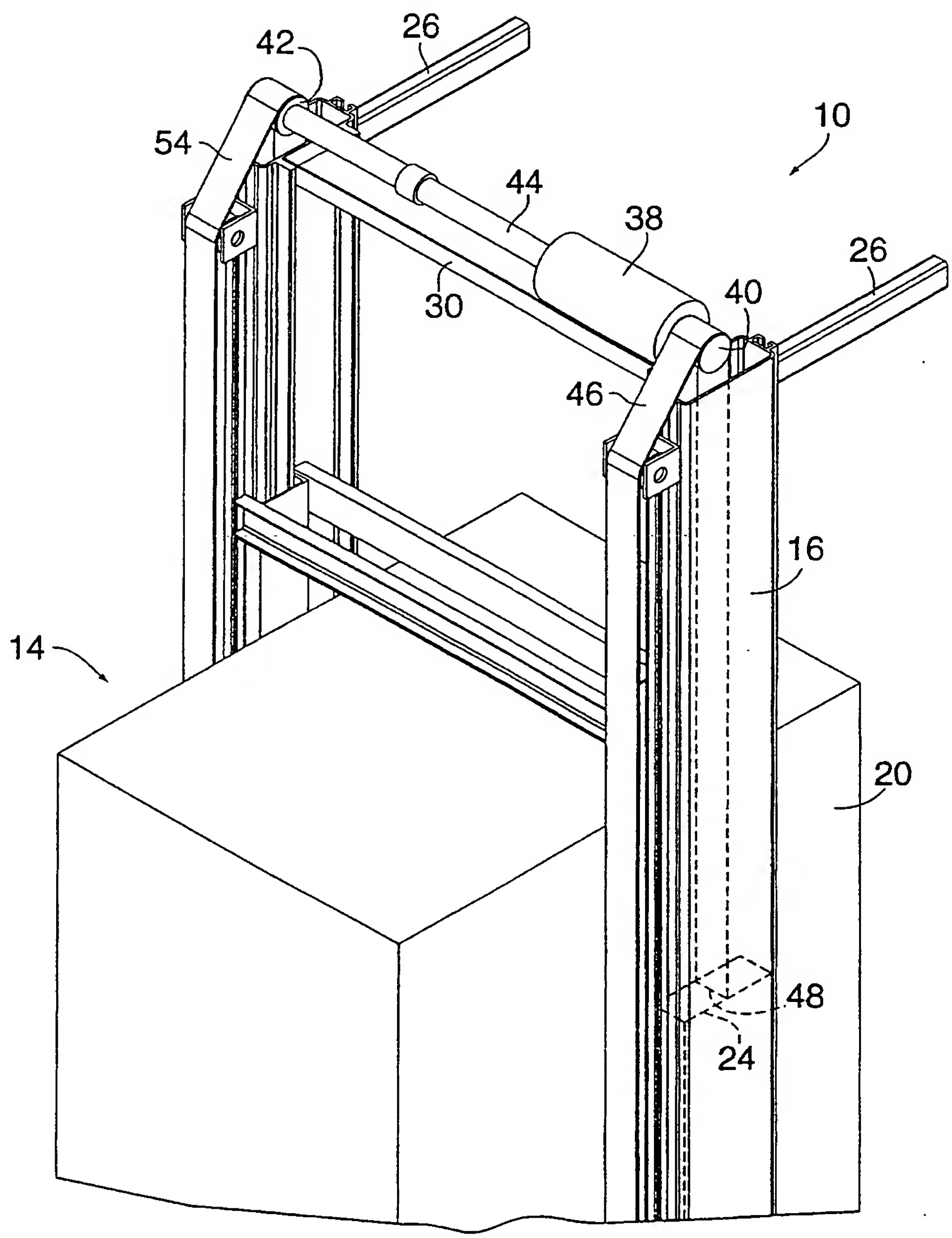


FIG. 2

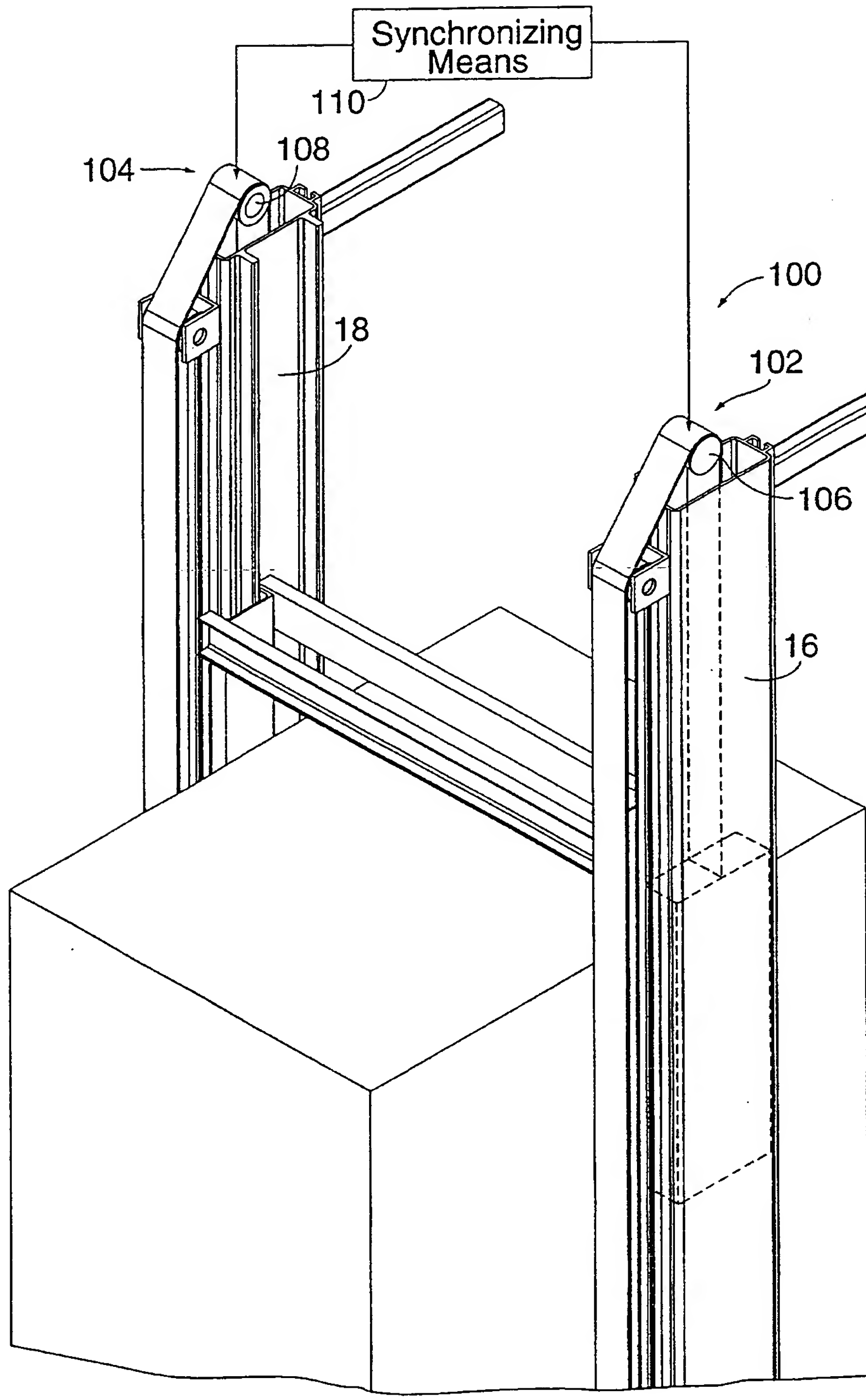


FIG. 3

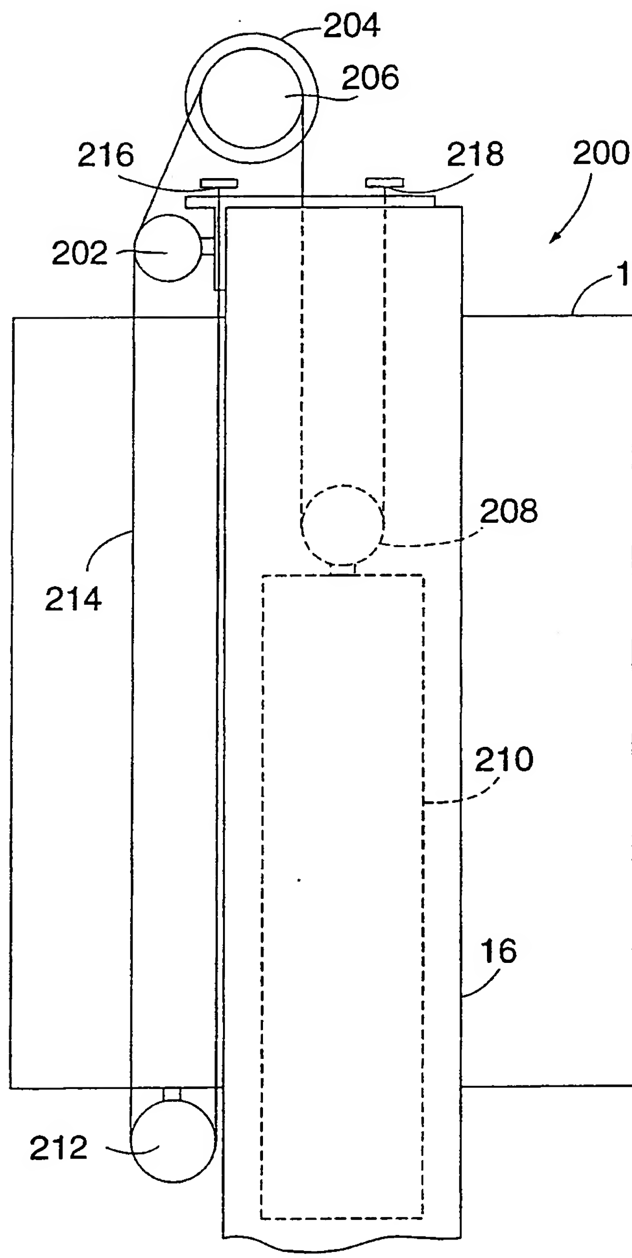
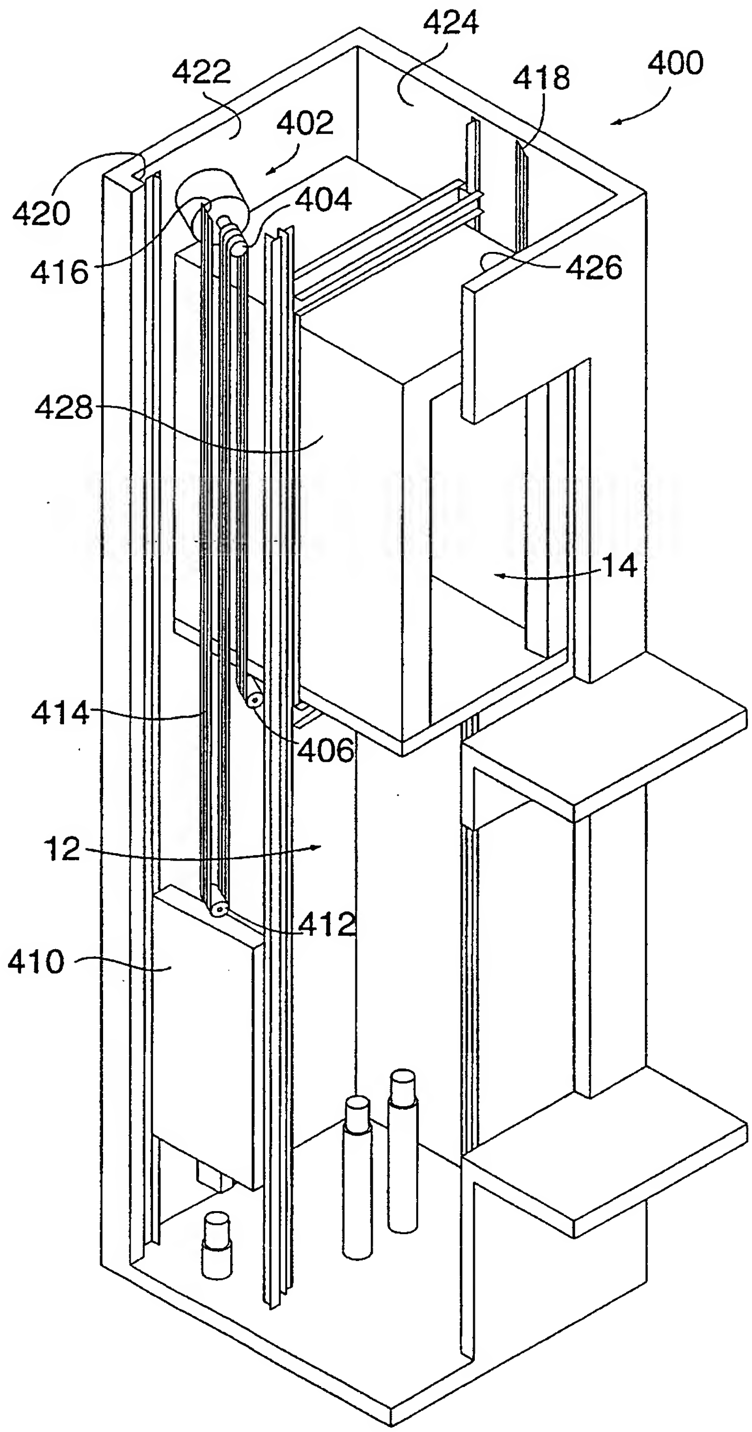


FIG. 4



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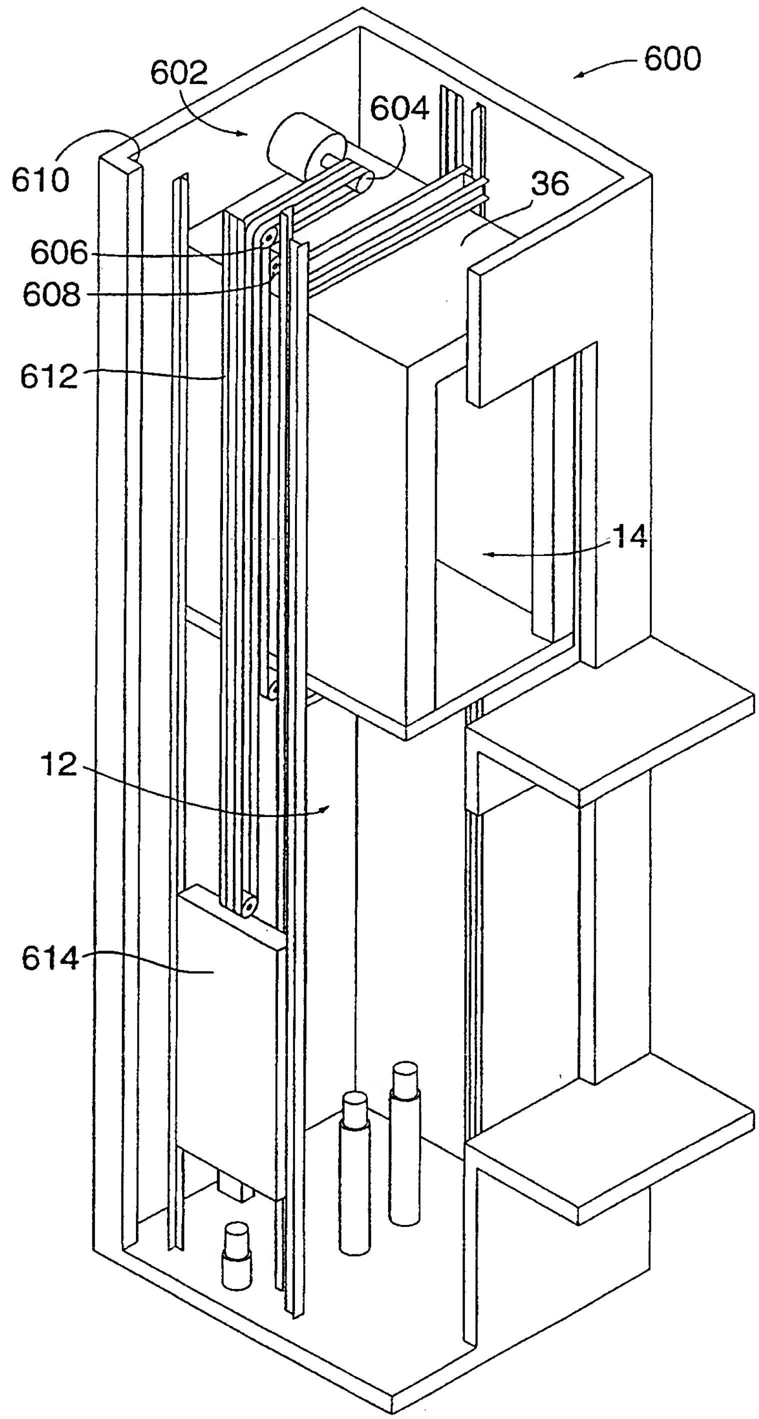

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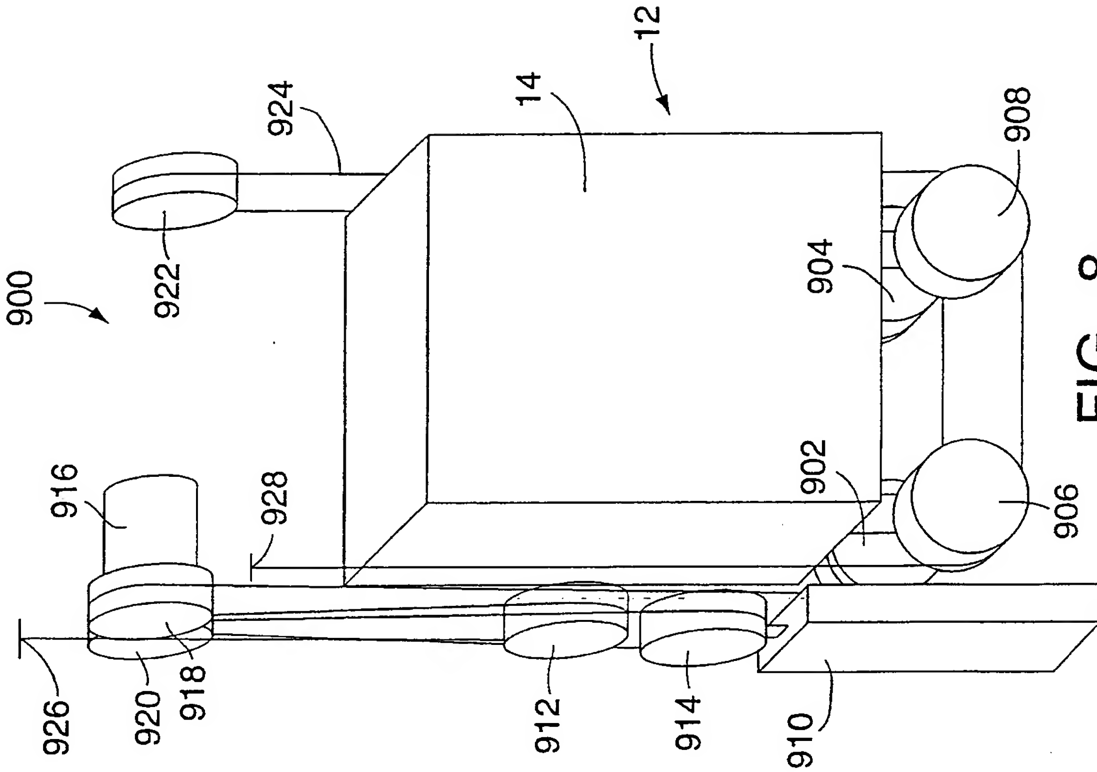
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FIG. 8

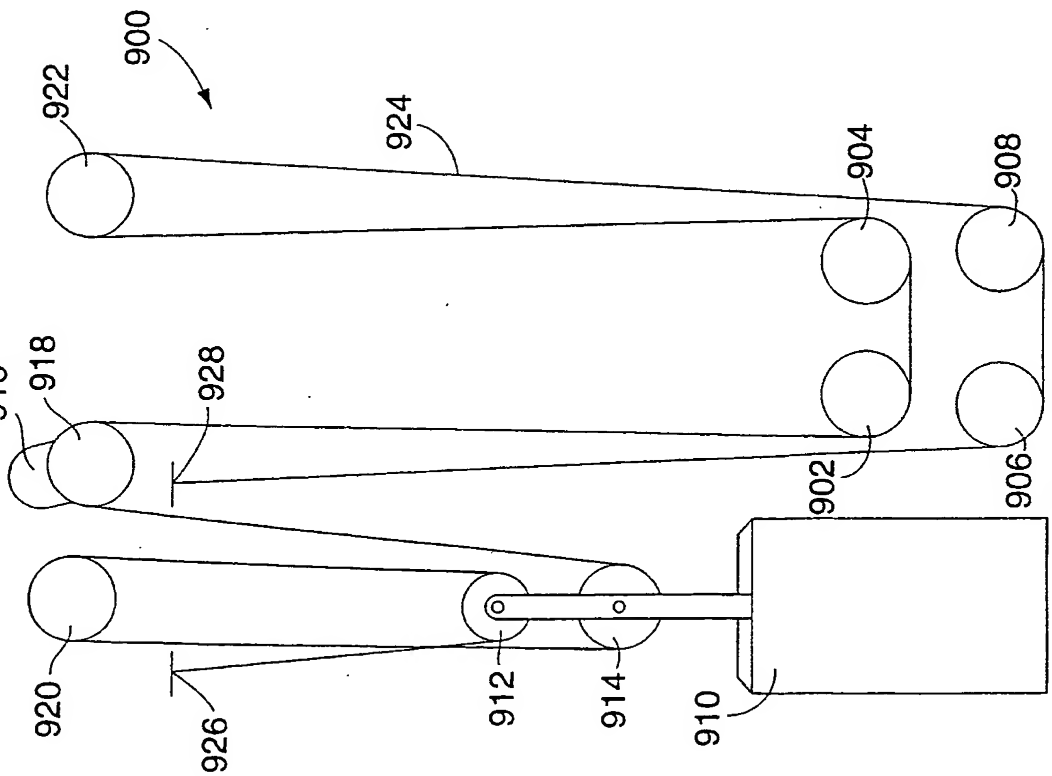
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FIG. 7

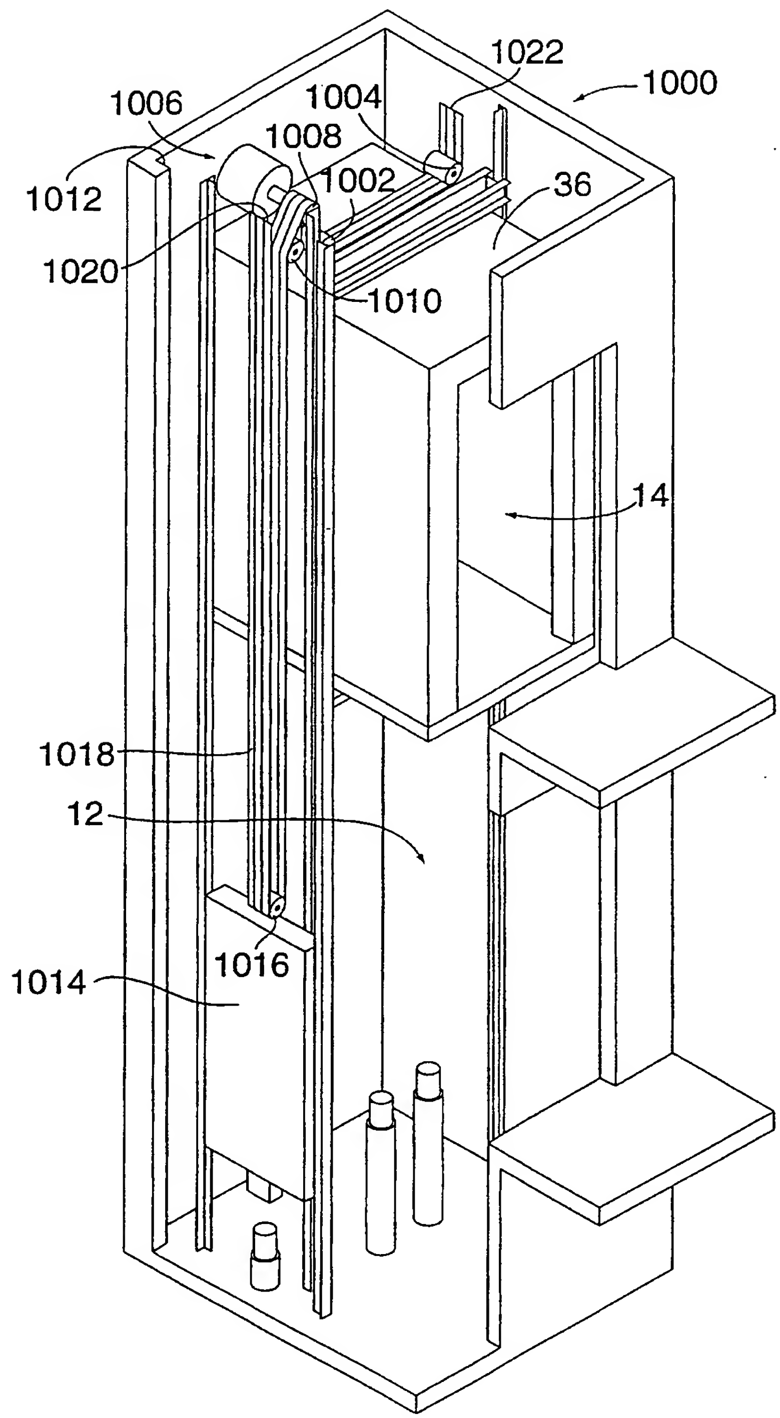
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FIG. 9

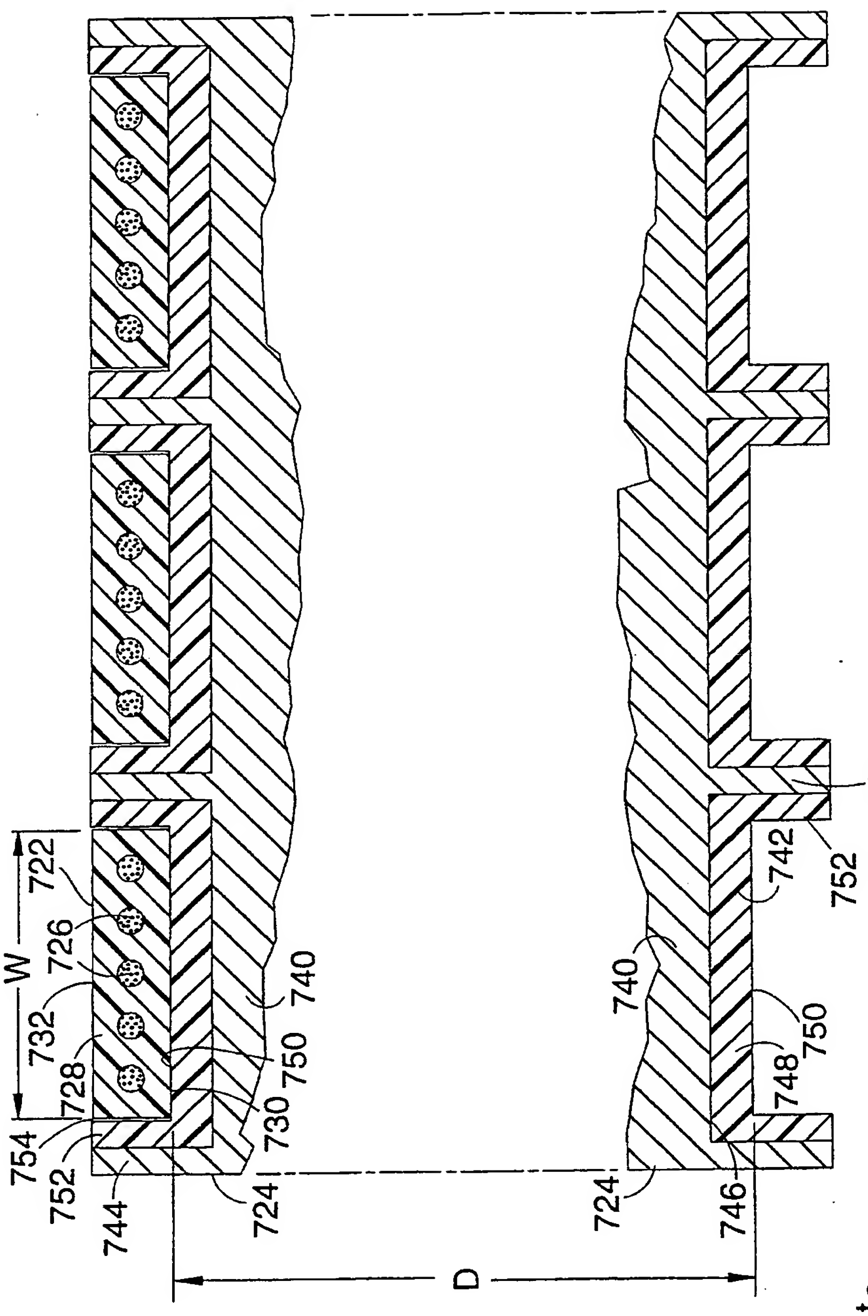
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FIG. 10

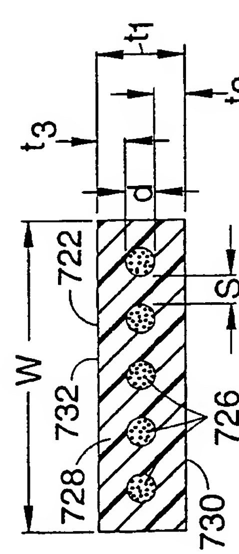
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FIG. 11

INTERNATIONAL SEARCH REPORT

Inter onal Application No
PCT/US 99/03648

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B66B9/02 B66B7/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B66B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and. where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	EP 0 710 618 A (KONE OY) 8 May 1996 see column 1, line 52 - line 56 see column 3, line 47 - line 51 see claims 2,3; figure 1	1-13,15 14
Y A	DE 23 33 120 A (VOGEL RUDOLF DR ING) 23 January 1975 see the whole document	1,12,15 5
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
24 June 1999	01/07/1999

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Salvador, D

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INTERNATIONAL SEARCH REPORT

Inter onal Application No
PCT/US 99/03648

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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